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INNOVATIVE TECHNOLOGY
Summary Report

Concrete Grinder

Deactivation and
Decommissioning Focus Area

Prepared for
U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

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DISCLAIMER

INNOVATIVE TECHNOLOGY
Summary Report

Concrete Grinder

OST Reference #2102

Deactivation and
Decommissioning Focus Area

Demonstrated at
Hanford Site
Richland, Washington

Purpose of this Document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available online at http://em-50.em.doe.gov.

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SECTION 1

EXECUTIVE SUMMARY

The Flex concrete grinder is a lightweight, hand-held concrete and coating removal system used for decontaminating or stripping concrete surfaces. The U. S. Department of Energy has successfully demonstrated it for decontaminating walls and floors for free release surveys prior to demolition work. The grinder is an electric-powered tool with a vacuum port for dust extraction and a diamond grinding wheel. The grinder is suitable for flat or slightly curved surfaces and results in a smooth surface, which makes release surveys more reliable. The grinder is lightweight and produces very little vibration, thus reducing worker fatigue. The grinder is more efficient than traditional baseline, tools at removing contamination from concrete surfaces (more than four times faster than hand-held pneumatic scabbling and scaling tools). Grinder consumables (i.e., replacement diamond grinding wheel) are more expensive than the replacement carbide parts for the scaler and scabbler. However, operating costs are outweighed by the lower purchase price of the grinder (50% of the price of the baseline scaler and 8% of the price of the baseline scabbler). Overall, the concrete grinder is an attractive alternative to traditional scabbling and scaling pneumatic tools. To this end, in July 1998, the outer rod room exposed walls of the Safe Storage Enclosure (SSE), an area measuring approximately 150 m^2 (1600 ft^2), may be decontaminated with the hand-held grinder.

■ Technology Summary

The Flex concrete grinder is an improved technology distributed by CS Unitec, Inc. (Norwalk, CT). The grinder is a hand-held concrete and coating removal tool that uses a diamond grinding wheel. This innovative technology was demonstrated for the U.S. Department of Energy's (DOE) C Reactor Interim Safe Storage (ISS) Project as part of the Large Scale Demonstration and Deployment Project (LSDDP) at DOE's Hanford Site in Richland, Washington.

The concrete grinder provides an attractive alternative to traditional methods of decontaminating walls and floors, which is typically accomplished using pneumatic scabbling and scaling tools. The concrete grinder (Flex Model LD 1509 FR) is a hand-held concrete and coating removal tool that includes a 12.7-cm (5-in.) diamond grinding wheel and vacuum port for dust extraction. The concrete grinder is suitable for flat (or slightly curved) walls and floors. For decontamination and decommissioning (D&D) projects, it can be used for radiological decontamination of general areas or hot spots on floors and walls for final or release radiological surveys. The demonstration conducted at the C Reactor decontaminated walls and floors in preparation for free release prior to demolition. This technology is suitable for DOE nuclear facility D&D sites or similar public or commercial sites that must be decontaminated.

Problem Addressed

The DOE is in the process of decontaminating and decommissioning many of its nuclear facilities throughout the county. Typically, the facilities undergoing D&D are contaminated, either chemically, radiologically, or both. In its D&D work, the DOE is in need of a tool capable of grinding contaminated concrete floors and walls from 1.5 mm to 3 mm (1/16" to 1/8") deep. The tool must be easy and economical to operate, capable of operating in ambient temperatures from 3 to 40°C and easy to decontaminate using conventional equipment. Use of the tool also had

to be safe for workers. The concrete grinder satisfies these needs and is an attractive alternative to scalers or single-piston scabblers, the traditional technologies used for similar operations.

Features and Configuration

- 12.5 cm (5 in.) diameter diamond wheel and vacuum shroud
- Powered by 110 VAC, 11 amps
- Light weight (2.8 kg, 6 lbs)
- Grinding depth is proportional to dwell time and number of passes

Potential Markets/Applicability

The concrete grinder is useful at DOE, U.S. Environmental Protection Agency (EPA), or U.S. Nuclear Regulatory Commission (NRC) sites in which contaminated concrete surfaces must be removed as part of the decontamination process. The technology could be used at other public or commercial facilities in which a traditional coating removal or concrete ablation system would be applicable. This technology can be used to decontaminate floors, walls, and other flat or slightly curved concrete structures. It can be used both on interior and exterior surfaces where fixed contamination exists and is especially advantageous where a smooth surface is desired. The tool is particularly useful where obstructions or structural geometry make larger concrete ablation devices impractical.

Advantages of the Improved Technology

The following table summarizes the advantages of the improved technology against the baseline in key areas:

Category	Comments
Cost	Purchase cost of the concrete grinder ($649) is less than two baseline technologies, single-piston pneumatic scabbler ($8,800) and pneumatic scaler ($1,250).
Performance	• Concrete grinder: 4.5 m^2/hr (48 ft^2/hr) @1.5 mm (1/16 in.) removal depth. • Scabbler: 1.13 m^2/hr (12 ft^2/hr) @ 1.5 to 3 mm (1/16 to 1/8 in.) removal depth • Scaler: 1.1 m^2/hr (11.8 ft^2/hr) @ 1.5 (1/16 in.) removal depth
Ease of Use	Lightweight; no specialized training no special site services
Secondary Waste Generation	Concrete grinder generates less concrete dust because depth of concrete surface removed is easier to control.
ALARA/Safety	Enhanced ALARA and safety reduced exposure time, vibration, and weight.

Operator Concerns

- Operator must check on integrity and operation of vacuum system.
- Another tool such as a needle gun maybe needed for corners.

Skills/Training

Training of field workers is minimal, provided that the trainees are proficient in operating pneumatic equipment for using the baseline tools.

■ Demonstration Summary

The Flex concrete grinder was demonstrated by the C Reactor Technology Demonstration Group during November, 1997.

Demonstration Site Description

This concrete grinder technology was demonstrated for the first time at the DOE's Hanford Site. Decontamination of a sample room walls was performed at the C Reactor to free release the walls prior to demolition. The demonstration was conducted by onsite D&D workers, who were instructed by the vendor prior to and during the demonstration.

Key Demonstration Results

- Both concrete grinder and the baseline tools successfully decontaminated concrete surfaces to below free release levels.
- The improved unit is adaptable for use with existing vacuum filtration systems
- The diamond grinder leaves a smoother surface than with baseline tools, so final release surveying is more reliable
- Costs using the improved technology are significantly lower than baseline costs. The concrete grinder costs much less than the baseline tools to purchase and costs 28% or more to operate. Two concrete grinders have been purchased for the C Reactor "tool box" and are being deployed.
- The hand-held, lightweight tool is particularly useful where obstructions or structural geometry make larger concrete ablation devices impractical.

Regulatory Issues

There are no special regulatory or permit requirements associated with implementation of this technology. Normal worker safety practices should be applied when using this tool in accordance with applicable regulations, particularly, 10 *Code of Federal Regulation* (CFR), Parts 20 and 835, and proposed Part 834, for protection of workers and the environment from radiological contaminants; 29 CFR Occupational Safety and Health Administration (OSHA) worker requirements.

Technology Availability

Diamond-wheel grinders have been available in the U.S. for over three years and are now readily available from concrete cutting tool suppliers. The Flex concrete grinder is distributed by CS Unitec, Inc. and was purchased from their regional representative, Andrews Machinery, Seattle, WA.

Technology Limitations/Needs for Future Development

The hand-held Flex concrete grinder is not appropriate for very large, wide-open concrete floors and slabs where push-type and wheel-powered diamond grinders and shavers are more efficient. The demonstration at the C Reactor ISS Project did not reveal any need to modify the Flex tool, except for a recommendation to increase the power rating for the motor.

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Other

All published Innovative Technology Summary Reports are available at http://em-50.doe.gov. The Technology Management System, also available through the EM-50 Web site, provides information about OST programs, technologies, and problems. The OST Reference # for the Hand-Held Concrete Grinder is 2102.

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The concrete grinder used for this demonstration is shown in Figure 1. Figure 2 shows the concrete grinder in

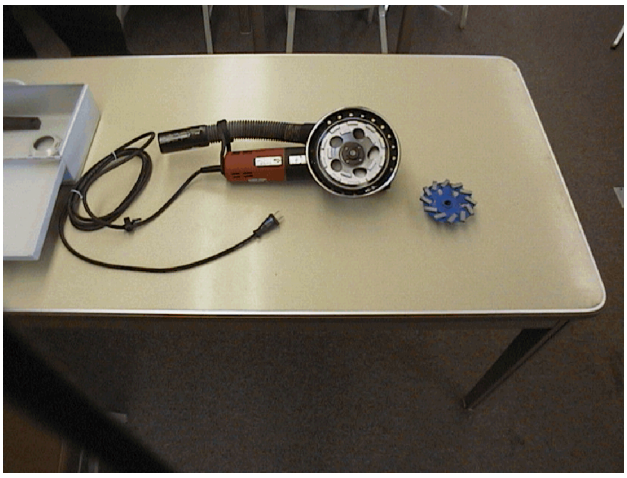

Figure 1. Grinder and Spare Wheel.

Figure 2. Decon in Sample Room X.

Components

12.7-cm (5-in.) diamond grinding wheel that operates at 10,000 revolutions per minute

Includes a 3.2-cm (1.25-in.) vacuum port for dust extraction

Aerodynamic internal and external air intakes for cooling and dust control

Operates via an electrical motor, rated at 11 amps

The concrete grinder (Model LD 1509 FR) is a hand-held concrete and coating removal tool that includes a walls and floors. The unit is lightweight, weighing only 2.7 kg (6 lb) and produces little vibration.

Depth of grinding is related to stay time and number of passes at any given location.

System Operation

Setup

It takes about 5 minutes to set up the system under normal operation conditions. Prior to initiating the decontamination, the setup involves the following steps:

- Freewheel check of the grinding wheel
- Check power cable for cuts or external wear
- Check vacuum port and exhaust system and connect all hoses
- Connect the power cords to 110 volt source
- Perform a system check to verify that all of the grinder and vacuum filtration components are operating.

Operation

The Hanford Site C Reactor concrete grinding decontamination was performed by one person using the concrete grinder (Flex Model LD 1509 FR). Replacement of the diamond grinding wheel will depend on wear and concrete removal rate.

SECTION 3

PERFORMANCE

Demonstration Overview

Site Description

The demonstration was conducted at the DOE's Hanford Site by Bechtel Hanford, Inc. (BHI), the DOE's Environmental Restoration Contractor responsible for the D&D program at Hanford. The purpose of the LSDDP is to demonstrate new, commercially-available and recently-developed technologies during DOE D&D operations. In the case of C-Reactor, the cost and performance of innovative technologies are comprehensively assessed while placing the reactor block into an interim storage mode for up to 75 years, or until the final disposal of the reactor's core is completed. The C Reactor ISS objectives include: reduce or hold constant future decommissioning costs, minimize releases to the environment, and reduce the frequency of inspections and potential risk to workers.

The U.S. DOE is in the process of decontaminating and decommissioning many of its nuclear facilities throughout the county. Facilities have to be dismantled and demolition waste must be sized into manageable pieces for handling and disposal. Typically, the facilities undergoing D&D are contaminated, either chemically, radiologically, or both. In its D&D work, the DOE was in need of a tool capable of grinding or shaving of contaminated concrete floors and walls up to 3 mm (1/8 in.) depth. The tool had to be easy and economical to operate, capable of operating in ambient temperatures from 3 to 40°C, and easy to decontaminate using conventional equipment. Use of the tool also had to be safe for workers. The Flex concrete grinder satisfies these needs and is an attractive alternative to traditional technologies such concrete scalers or single-piston scabblers used for similar operations.

The demonstrations of the diamond grinder and the baseline technologies were conducted in various sample rooms in the C Reactor facility. Approximately 5 m^2 (54 ft^2) of floors and walls were decontaminated by using the grinder to remove 1.5 mm (1/16 in.) depth from the concrete surfaces.

Performance Objectives

Objectives of the demonstration included the following desired capabilities and design features for the equipment:

A. Capability of removing concrete using a tool weighing less than 5 kg (10 lb).

B. Inclusion of a dust collection shroud that has a fitting suitable for attaching a vacuum hose connected to an existing onsite HEPA filtration system.

C. Fitted with a power cord and energized with commonly available electric power.

Demonstration Chronology

The concrete grinder decontaminated 5 m^2 (54 ft^2) of floors and walls in 68 min. It removed 1.5 mm (1/16 in.) or more of concrete in easy circular motions. The diamond-tip blades are cooled by external shroud holes, which allow air to pass over the blades and into the internal discharge holes to the vacuum system -- an innovative design.

The demonstration was conducted during November 1997 at a sample room in the Hanford Site C Reactor building.

Improved Technology

The Flex Model LD 1509 FR grinder marketed by CS Unitec, Inc. (Norwalk, CT) is a hand-held concrete and coating removal tool that includes a 12.7-cm (5-in.) diamond grinding wheel and vacuum port for dust extraction, suitable for flat (or slightly curved) walls and floors. The unit is designed with aerodynamic internal and external air intakes, to be used with a vacuum filtration unit vacuum port) for dust-free operations. The LD 1509 FR is rated at 11 amps / 10,000 rpm and weighs only 6 lbs. Depth of grinding is related to stay time and number of passes at any given location.

Baseline Technology

The baseline demonstration was conducted on October 7, 1997 through November 3, 1997, on the interior C Reactor Sample Rooms A and B. Both sample rooms required 1.5 to 3 mm (1/16 in. - 1/8 in.) concrete removal from floors and walls (and for small areas to 6 mm (1/4 in.)). The floors of both sample rooms were painted with lead-based paint.

The baseline hand-held decontamination tools demonstrated were a pneumatic scaler and single-piston scabbler, connected to a HEPA vacuum filtration system.

The scaler is designed to remove concrete surfaces between 1.5 to 3 mm (1/16 in. and 1/8 in.) depths. It contains a flapper device used to strike concrete surfaces. This tool is also useful in hard-to-reach horizontal areas, such as under equipment. The scaler has a port for connecting to vacuum filtration system. The other pneumatic baseline tool demonstrated was a scabbler designed to remove concrete surfaces between 3 to 6 mm (1/8 in. to 1/4 in.) depths. A single-piston scabbler can reach medium-congested areas and next to walls/floor intersections. The scabbler uses vacuum exhaust for low-dust operations (suction at striking point).

■ Technology Demonstration Results

Key Demonstration Results

The concrete grinder system was successfully demonstrated at the C Reactor with the following results:

- Both the concrete grinder and the baseline tools successfully decontaminated concrete surfaces to below free-release levels.
- The grinder is adaptable for to use with existing vacuum filtration systems
- The innovative tool leaves a smoother surface than with baseline tools, so final release surveying is more reliable.
- Costs using the innovative technology are significantly lower than baseline costs. The concrete grinder, with a production rate of 4.5 m^2/ hour (48 ft^2/ hour) for 1.5 mm (1/16 in.), far exceeded the single-piston pneumatic scabbler 1.13 m^2/ hour (12 ft^2/ hour) and pneumatic scaler 1.1 m^2/ hour (11.8 ft^2/ hour) production rate.
- The hand-held, lightweight tool is particularly useful where obstructions or structural geometry make larger concrete ablation devices impractical.

■ Comparison of Improved Technology to Baseline

Table 1. Improved versus baseline performance

Production Parameter	Concrete Grinder	Single-Piston Scabbler[a]	Scaler[b]
Area Decontaminated	5.0 m^2 (54 ft^2)	12.2 m^2 (32 ft^2)	5.5 m^2 (59 ft^2)
Depth removed	1.5 mm (1/16 in.)	1.5 to 3 mm (1/16 -1/8 in.)	1.5 mm (1/16 in.)
Duration of grinding	1.13 hr	11.8 hr	5.0 hr
Area/hr at 1.5 mm (1/6 in.) depth[c]	4.5 m^2 (48 ft^2)	1.13 m^2 (12 ft^2)	1.11 m^2 (11.8 ft^2)

Notes:
a. Operation of the scabbler was more difficult than the other tools due to its increased weight and high vibration.
b. The diamond grinder and the scaler were both user friendly (lightweight).
c. The scabbler lacked the precision to remove the concrete walls surface to a uniform depth of 1.5 mm (1/16 in.). The device is designed to remove material to a minimum 3 mm (1/8 in.) deep, but actually removed material to a depth ranging from 1.5 to 3 mm (1/16 to 1/8 in.).

Table 2. Comparison of improved and baseline parameters

Activity or Feature	Improved	Baseline	
	Grinder	Scabbler	Scaler
Setup[a], minutes	4	5	5
Production Rate (from Table 1) @ 1.5 mm depth	4.5 m^2/hr (48 ft^2/hr)	1.13 m^2/hr (12 ft^2/hr)	1.11 m^2/hr (11.8 ft^2/hr)
Flexibility	Less than scaler[b]	Less than scaler[b]	Better than grinder
Safety	Same	Same	Same
Durability	Fair[c]	Good	Good
Ease of operation	Easy; weighs less and less vibration than baseline tools	Easy	Easy
Weight	2.7 kg (6 lb)	22.7 kg (50 lb)	3 kg (6.5 lb)
Waste generation	Slightly less dust generation than baseline tools	Slightly more dust/and particulate generation than grinder	Slightly more dust/and particulate generation than grinder
Utility requirements	115 VAC	Compressed air	Compressed air
Training	Same	Same	Same

NOTES:
a. Average times to connect to electric outlet or air supply unit and test before use. Note that the innovative grinder plugged into an electric receptacle, whereas the baseline tools required setting up an air compressor and connecting an air supply line. Both the grinder and baseline tools used a HEPA system, which required much more time to be set up (~ 1 day).
b. The scaler has somewhat more flexibility than the scabbler or the innovative grinder for reaching under equipment that is on short support legs.
c. The grinder has an electric motor that can burn out if handled or used incorrectly.

The conditions for an individual job directly affect the manner in which D&D work is performed. The improved and baseline technologies presented in this report are based upon a specific set of conditions or work practices ound at the Hanford Site. These conditions are summarized in Table 3. This table is intended to help the technology user identify work item differences between baseline and improved technologies.

Table 3. Summary of Variable Conditions

Variable	Innovative Technology	Baseline Technology
Scope of Work		
Quantity and type of material decontaminated in test areas	5 m^2 (54 ft^2) of floor and walls surfaces decontaminated in one room	12.2 m^2 (13 ft^2) of floor and walls surfaces decontaminated with a scabbler and 5.4 m^2 (59 ft^2) with a scaler in 2 rooms
Location of test area	Reactor Building, Sample Room X	Reactor Building, Sample Rooms A & B
Nature of work	Surfaces were concrete.	Surfaces were concrete.
Work Environment		
Fixed or removable contamination in the test areas	Contamination that might be present is fixed	Contamination that might be present is fixed
Floor in test areas	Unobstructed	Unobstructed
Work Performance		
Technology acquisition means	Rented tool on a daily basis, with option to purchase. (Grinder was purchased at the end of the demonstration.)	Purchased tools
Compliance requirements	Must meet 10 CFR 835, Appendix D (See BHI-SH-02, Vol. 2, Safety and Health Procedures, Unconditional surface Contamination Release, 6/27/97)	Must meet 10 CFR 835, Appendix D (See BHI-SH-02, Vol. 2, Safety and Health Procedures, Unconditional surface Contamination Release, 6/27/97)
Work Process Steps		
Operation	Attach vacuum hose to filtration unit and plug in cord to electrical power supply. Inspect grinding wheel occasionally during intermittent use, and change the wheel as necessary.	Attach vacuum hose to filtration unit and pneumatic hose to air compressor. Inspect scabbler head or scaler flappers occasionally during intermittent use, and change as necessary.

Skills/Training

Field technicians should be trained in operating electrical and pneumatic hand tools.

Operational Concerns

Both the baseline and the improved tools should be used with a HEPA vacuum filtration unit, and the workers must be vigilant to ensure that the vacuum hose stays connected properly and that a suitable level of vacuum is maintained.

None of the technologies compared here are capable of removing concrete at inside corners of walls or at the walls/floor junctions. The degree of this shortcoming varies with the tool, but is the least advantageous with the scabbler due to its bulkier configuration and weight. Also, because of its height, the scabbler has more limitations in tight areas. Both the grinder and the scaler are better than the scabbler at getting closer to corner junctions and in and around tight spots with the grinder performing slightly better than the scaler. To reach the walls corners and junctions, other tools such as an air-driven needle gun must be used.

Successes

- Maneuverability around/over walls protrusions
- Simple to deploy, requiring minimal skill levels
- Better production rate than the baseline tools
- Less vibration than the baseline tools
- Light weight.

Shortfalls

A more powerful motor could provide a higher degree of tool durability. (The baseline tools are pneumatic and do not have a potential motor burnout problem.)

Meeting Performance Objectives

The objectives listed in the Demonstration Overview section were met.

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVE TECHNOLOGIES

■ Technology Applicability

- This technology can be used to decontaminate floors, walls, and other concrete surfaces.
- The concrete grinder is applicable to radiologically contaminated sites with surface contamination or suspect surface contamination designated for D&D activities and release (DOE, EPA or NRC sites).
- The concrete grinder can also be used for any concrete resurfacing or deep-cleaning operation, especially where a smooth finish is desired.
- The system may be used both on interior and exterior surfaces.

■ Competing Technologies

- Alternative hand-held tools to the diamond-wheel grinder are the baseline tools tested. Larger, push-type, wheel-powered and track-mounted decontamination devices are not comparable and are suitable for wide, open surfaces only. These hand-held tools augment the larger devices. Other methods of concrete surface decontamination technologies, such as laser ablation, media blasting, cryogenic nitrogen blasting and carbon dioxide pellet blasting take longer to set up and demobilize, cost more for equipment and may not have as high a production rate.
- A concrete spaller, also demonstrated at the Hanford Site C Reactor, has a comparable production rate, but costs more to purchase and is much heavier. The spaller does not leave a smooth surface, making post-decontamination surveys less reliable. The spaller is better for removing concrete surfaces to depths of more than 3 mm (1/8 in.).

■ Patents/Commercialization/Sponsors

- Diamond-wheel grinders have been available in the U.S. for over three years and are now readily available from concrete cutting tool suppliers.

SECTION 5

COST

Introduction

This cost analysis compares the Flex hand-held grinder improved technology for removing concrete walls surfaces to two different baseline technologies and determined that the innovative technology saves approximately 40% over each baseline technology.

Costs for the improved technology are based on one decontamination technician using the grinder inside a rad-zone assisted by one decontamination technician working outside the radiation zone. Other costs included for the improved technology are mobilizing and setting up the equipment necessary to run the grinder, RCT monitoring for radiological contamination, breaking down and demobilizing equipment at the completion of the work, and disposal of waste generated from the grinding operation.

The two baseline technologies are the hand-held scaler and the hand-held scabbler. Each of the baseline technologies were compared to the improved technology. The scaler removes concrete surface utilizing a wheel of rotating tungsten carbide flaps. The other baseline tool is a single-piston scabbling tool that removes concrete by striking the surface at a right angle with carbide-tipped rods. Costs for the baseline technologies are based upon the same number of D&D workers used for the improved technology conducting the same basic removal activities, but using the two different hand-held tools. As with the innovative technology, other costs for the baseline technologies include mobilization and demobilization of equipment, RCT monitoring, and waste disposal.

Activities included for cost comparison are as follows:

Innovative Technology

- Setting up the air-driven Vac-Pac™ HEPA filtration unit & air compressor in the work area & wrapping powered air-purifying respirators (PAPRs)
- Setting up the concrete grinder
- Donning & doffing personal protective equipment (PPE)
- Removing concrete walls surface to a depth of 1.5 mm (1/16 in.) with the Flex grinder
- Monitoring workers & waste stream for radiological contamination
- Disassembling equipment & air & vacuum hoses
- Disposing of removed concrete, PPE, & plastic sheeting & sleeving

Baseline Technologies

- Setting up the air-driven Vac-Pac™ HEPA filtration unit & air compressor in the work area & wrapping powered air-purifying respirators (PAPRs)
- Setting up the scaler and scabbler
- Donning & doffing personal protective equipment (PPE)
- Removing concrete walls to a depth of 1.5 mm (1/16 in.) with the scaler and removing concrete walls surface to a depth of 1.5 to 3 mm (1/16 to 1/8 in.) with the scabbler
- Monitoring workers & waste stream for radiological contamination
- Disassembling equipment & air & vacuum hoses
- Disposing of removed concrete, PPE, & plastic sheeting & sleeving

Cost Data

The Flex hand-held grinder technology is available from the equipment supplier as follows:

Table 4. Improved technology acquisition costs

Acquisition Option	Item	Cost[1]
Equipment Purchase	• Flex LD 1509 FR concrete grinder • Replacement 12.7-cm (5-in.) diamond grinding wheel good for 47 m^2 @ 1.5 mm removal (500 ft^2 @ 1/16 in.) or approximately 10.5 hours of use	$649 $205
Equipment Rental	• Flex LD 1509 FR concrete grinder (customer purchases the diamond grinding wheel)	$25/day $75/week $225/month

(1) All costs are based on 1997 pricing data made available from the Seattle-based equipment supplier, Andrews Machinery.

The two baseline tools are available at the following costs:

Table 5. Baseline technology acquisition costs

Acquisition Option	Item	Cost[1]
Equipment Purchase[2]	Baseline Technology : • Scaler (standard) • Replacement tungsten carbide flaps good for 45 m^2 @ 1.5 mm removal (480 ft^2 @ 1/16 in.) or approximately 40 hours of use	 $1,250 6 @ $29.30 or $175.80
Acquisition Option	**Item**	**Cost[1]**
Equipment Purchase[2]	Baseline Technology : • Scabbler (single-piston) • Replacement tungsten carbide scabbling bit (good for 233 m^2 @ 1.5 mm to 3 mm removal (2,500 ft^2 @ 1/16 in. to 1/8 in.) or approximately 223 hours of use	 $8,800 $335

(1) All costs are based on 1997 pricing data made available from equipment supplier.
(2) No rental agreement is available for equipment directly through the factory.

Observed unit costs and production rates for principal components of the demonstrations for both the innovative and baseline technologies are presented in Table 6:

Table 6. Summary of unit costs

IMPROVED TECHNOLOGY - LD 1509 FR Concrete Grinder		
Cost Element	**Production Rate**	**Unit Cost**(1)
Removing concrete walls to depth 1.5 mm (1/16 in.)	4.5 m^2/hr (48 ft^2/hr)	\$31.43/m^2 (\$2.92/ft^2)
Baseline Technology - Scaler (Standard)		
Cost Element	**Production Rate**	**Unit Cost**(1)
Removing concrete walls to depth 1.5 mm (1/16 in.)	1.11 m^2/hr (11.8 ft^2/hr)	\$112.70/m^2 (\$10.47/ft^2)
Baseline Technology - Scabbler (Single-Piston)		
Cost Element	**Production Rate**	**Unit Cost**(1)
Removing concrete walls to depth 1.5 to 3 mm (1/16 to 1/8 in)(2)	1.13 m^2/hr (12 ft^2/hr)	\$111.62/m^2 (\$10.37/ft^2)

(1) Unit costs and production rates shown do not include mobilization, other losses associated with non-productive portions of the work (such as suit-up, breaks and etc.), RCT support, or waste disposal. This table shows unit costs at their elemental level, free of site-specific factors. The unit cost for removing concrete walls surface is the unit cost shown as the line item entitled: "Remove Concrete Walls Surface Down 1/16th - inch with...(*specific tool)"* in Tables C-2, C-3.1 and C-3.2 of Appendix C. These tables can be used to compute site-specific costs by inserting quantities and adjusting the units for conditions unique to an individual D&D job.

(2) The scabbler lacked the precision to remove the concrete walls surface to a uniform depth of 1.5 mm (1/16 in.). The device is designed to remove material to a minimum 3 mm (1/8 in.) deep, but actually removed material to a depth ranging from 1.5 to 3 mm (1/16 to 1/8 in.).

■ Costs

Figure 3 is a chart displaying a comparison of costs between the improved and baseline technologies for 1.5 mm (1/16-in.) depth concrete floor surface removal (1.5 to 3 mm (1/16 to 1/8 in.) for the baseline scabbler). The comparison is based on actual costs of technology demonstrations at the Hanford Site C-Reactor.

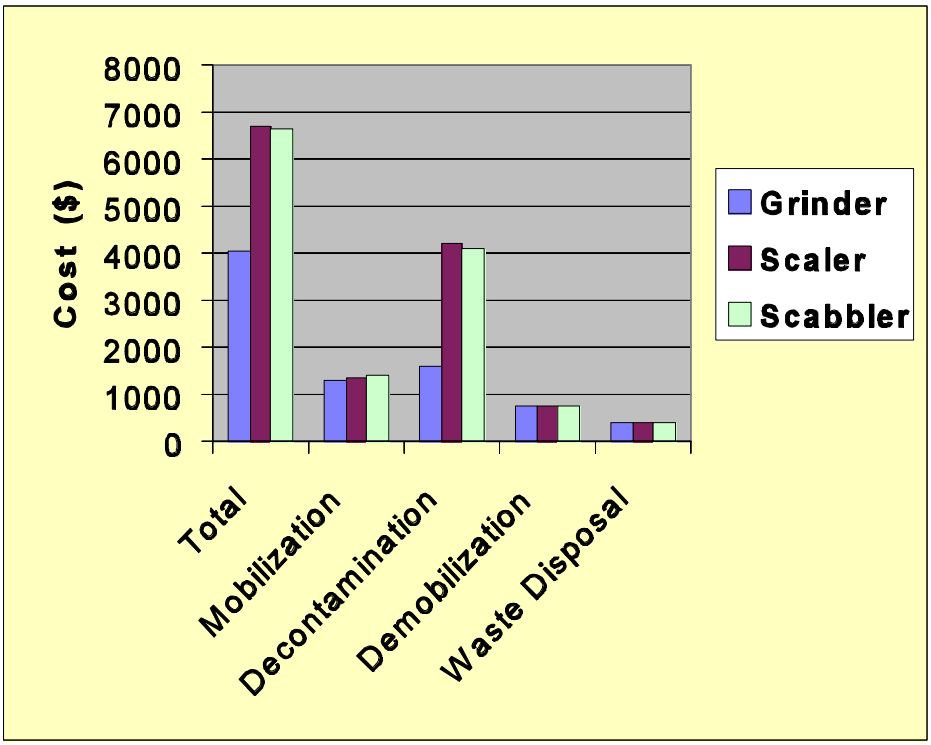

Figure 3. Improved technology costs vs. baseline costs.

The Flex grinder has advantages over the two baseline tools in terms of ease of use, flexibility, and ability to remove material to greater depths without sacrificing much productivity. However, one must consider the useful life of the diamond grinding wheel. As seen in Table 4, a replacement diamond grinding wheel costs $205.00. The manufacturer-recommended amount of walls surface that can be removed to 1.5 mm (1/16-in.) depth between wheel changes is 47 m^2 (500 ft^2). Thus, at the demonstrated productivity of 4.5 m^2 /hr (48 ft^2/hr), the life of a typical wheel is 500÷48 or 10.4 hours. When the labor for replacing a wheel is added in (one decontamination worker at 10 minutes or $5.33), the equipment-only operating cost for the tool is ($205.00 + $5.33) ÷ 10.4 hrs or $20.22/hr. Based on a similar calculation made for replacement flaps for the scaler and replacement bits for the scabbler, equipment-only operating costs are $4.53/hr and $1.53/hr, respectively.

The observed production rate for the scaler varied over a range of 0.53 m^2/hr (5.73 ft^2/hr) to 1.67 m^2/hr (17.96 ft^2/hr) depending upon the specific conditions of the work. The estimate is based on 1.10 m^2/hr (11.8 ft^2/hr). A substantial variation from the production rate used in this cost analysis is possible (depending on conditions present at other work locations) and could possibly change the conclusions of the cost comparison.

The two baseline technologies were demonstrated in Sample Rooms A and B, located in the northeast reactor area. The scaler technology was demonstrated on 5.5 m^2 (59 ft^2) of wall area and the scabbler was demonstrated on 12.2 m^2 (132 ft^2) of wall area.

To create an equitable comparison among all three technologies, the wall area demonstrated for the innovative technology and the wall area demonstrated for the scaler technology have been extrapolated to match the wall area demonstrated for the scabbler technology. The productivity measured during the demonstration for each of these two technologies (listed in Table 2) is multiplied by the 12.2 m^2 (132 ft^2) in order to calculate the increase in hours for the extrapolation. All other associated costs, such as setting up equipment, donning/doffing PPE, disassembling equipment, and waste disposal are based on hours and material quantities actually experienced during the demonstration.

■ Cost Conclusions

For removing 1.5 mm (1/16 in.) of concrete walls surface and based on the conditions and assumptions established for the demonstration, the Flex grinder saves approximately 40% over each of the two baseline technologies. The primary reason for this is the increased productivity (or rate of removal) advantage the innovative technology holds over the two baseline technologies (see Table 6). The slower removal rate experienced with the baseline technologies also means more days must be worked in the contamination area, thus requiring more RCT support time and more time spent donning/doffing PPE.

In summary, increased productivity with the grinder outweighs the higher operating costs of this tool (with respect to the baseline tools). The grinder's increased productivity and low purchase price are excellent reasons to include this tool as a resource for decontamination and demolition work.

SECTION 6

REGULATORY/POLICY ISSUES

■ Regulatory Considerations

- The concrete grinder is a concrete decontamination tool used for cleaning contaminated concrete surfaces; therefore, there are no special regulatory permits required for its operation and use.
- The system can be used in daily operation under the requirements of 10 CFR Parts 20 and 835, and proposed Part 834 for protection of workers and environment from radiological contaminants; 29 CFR, OSHA worker requirements.
- Although the demonstration took place at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site, no CERCLA requirements apply to the technology demonstrated.

■ Safety, Risk, Benefits, and Community Reaction

Worker Safety

- Normal radiation protection worker safety procedures used at the facility would apply. Unless field tests show that the vacuum system capture is collecting airborne particulate effectively, respiratory protection should be included.
- In order to avoid spreading contamination, the operator must be vigilant to ensure that the vacuum hose connections remain secured, that adequate vacuum is maintained, and that the filters are operating normally.
- National Electric Code requirements should be met for the 115-AC power employed.

Community Safety

- It is not anticipated that implementation of diamond grinding technology would present any adverse impacts to community safety if vacuum filtration is properly utilized.

■ Environmental Impact

- It is not anticipated that implementation of diamond grinding technology would present any adverse impacts to the environment if vacuum filtration is properly utilized.

■ Socioeconomic Impacts, and Community Perception

- No socioeconomic impacts are expected in association with use of this technology.

SECTION 7

LESSONS LEARNED

Implementation

- No special implementation concerns apply to diamond-wheel grinding technology. Ordinary electrical power supply voltage and circuitry are used. An adequate vacuum filtration unit is needed.

Technology Limitations/Needs for Future Development

- Due to the physical size and geometry of the tool, the hand-held grinder is not appropriate for wide-open concrete floors and slabs where push-type and wheel-powered diamond grinders and shavers can be used more efficiently.

- Currently, there is no need to modify the tool demonstrated at the Hanford Site C Reactor.

Technology Selection Considerations

- The technology is suitable for DOE nuclear facility D&D sites or similar sites where certain concrete structures must be decontaminated to facilitate property transfer or release.

- The hand-held lightweight tool demonstrated should be considered where obstructions or structural geometry make larger concrete ablation devices impractical or where a smooth finish is desired.

APPENDIX A

REFERENCES

10 CFR Part 835, "Occupational Radiation Protection," as amended.

Proposed 10 CFR Part 834, "Environmental Radiation Protection," as proposed.

10 CFR Part 20, "Occupational Radiation Protection," as amended.

29 CFR Part 1910, "General Industry Occupational Safety and Health Standards," as amended.

29 CFR Part 1926, "Construction Occupational Safety and Health Standards," as amended.

Means Construction Equipment Cost Data, R.S. Means Co., Kingston, MA 1997.

Office of Management and Budget (OMB) Circular No. A-94 for Cost Effectiveness Analysis

USACE, 1996, *Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary* (HTRW RA WBS), U.S. Army Corps of Engineers, Washington, D.C.

APPENDIX B

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Description
ALARA	as low as reasonably achievable
BHI	Bechtel Hanford, Inc.
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
DOE-RL	DOE- Richland Operations Office (WA)
FETC	Federal Energy Technology Center
HEPA	high-efficiency particulate air (filtration)
ICT	Integrated Contractor Team
ISS	Interim Safe Storage
LSDDP	Large-Scale Demonstration and Deployment Project
PAPR	powered air-purifying respirator
PPE	personal protective equipment
RCT	radiological control technician
USACE	U.S. Army Corps of Engineers
WBS	work breakdown structure

APPENDIX C

COST COMPARISON

■ Technology Cost Comparison

This cost analysis compares the Flex hand-held grinder improved technology for removing concrete walls surfaces to two different baseline technologies. Costs for the improved technology are based on one decontamination technician using the grinder inside a radiation zone assisted by one decontamination technician working outside the rad-zone. Other costs included for the innovative technology are mobilizing and setting up the equipment necessary to run the grinder, RCT monitoring for radiological contamination, breaking down and demobilizing equipment at the completion of the work, and disposal of waste generated from the grinding operation.

Costs for the baseline technologies are based upon the same number of D&D workers used for the improved technology conducting the same basic removal activities, but using the two different hand-held tools. As with the innovative technology, other costs for the baseline technologies include mobilization and demobilization of equipment, RCT monitoring, and waste disposal.

The selected basic activities analyzed come from the Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary (HTRW RA WBS), USACE, 1996. The HTRW RA WBS, developed by an interagency group, used in this analysis to provide consistency with the established national standards.

Some costs are omitted from this analysis so that it is easier to understand and to facilitate comparison with costs for the individual site. The overhead and general and administrative (G&A) mark up costs for the site contractor managing the demonstration are omitted from this analysis. Overhead and G&A rates for each DOE site vary in magnitude and in the way they are applied. Decision makers seeking site-specific costs can apply their site's rates to this analysis without having to first back-out the rates used at the Hanford Site.

The following assumptions were used as the basis of the cost analysis:

- Oversight engineering, quality assurance, and administrative costs for the demonstration are not included. These are normally covered by another cost element, generally as an undistributed cost;
- The procurement cost of 7.5% was applied to applied to all equipment costs to account for costs of administering the purchase (this cost is included in the hourly rate);
- The equipment hourly rates for the scaler and for the scabbler, represent the Government's ownership, and are based on general guidance contained in Office of Management and Budget (OMB) circular No. A-94 for Cost Effectiveness Analysis.
- The standard labor rates established by the Hanford Site for estimating D&D work are used in this analysis for the portions of the work performed by local crafts;
- The analysis uses an eight-hour work day;
- Additionally, an anticipated life of 5 years and an average usage of 500 hrs/year are used in the calculation for the grinder, the two baseline technology tools, and the VAC-PAC HEPA filtration unit.

Innovative Technology - FLEX LD 1509 FR Concrete Grinder

MOBILIZATION (WBS 331.01)

Collect Tools from Storage & Stage at the Work Site: This activity includes time for moving the grinder, VAC-PAC™ HEPA filtration unit and air compressor from Connex™ boxes into a truck bed and moving the equipment to the work area. It also includes plugging in the grinder, connecting the vacuum hose to it and installing the diamond grinding blade. The activity is measured as one each for the demonstration.

Set Up the VAC-PAC™ HEPA filtration unit in the Work Area: This activity involves setting up the VAC-PAC™ and it's hoses. The activity is measured as one each for the demonstration.

Sleeve Vacuum and Air Hoses: This activity involves using duct tape to attach plastic tubing to the vacuum and air hoses to prevent surface contamination of the hoses in the Rad Zone. The activity is measured as one each for the demonstration.

Wrap PAPRs: On a daily basis, 3 to 5 powered air-purifying respirator (PAPR) units are required to be wrapped with a plastic cover along with the hose that delivers air to the mask. The measure is taken to prevent contaminating the units which, if it occurred, would mean discarding them. Costs for this item are measured on a daily basis.

DECONTAMINATION (WBS 331.17)

Pre-Work Briefing & Safety Meeting: This activity involves everyone who will work in or around the contamination area. This meeting is required every day of demolition work.

Don & Doff PPE: This cost item includes time for each of 2 D & D workers and 1 RCT to fully suit-up in personal protective clothing (PPE) for demolition work as well as material costs for the PPE. Time for removing PPE at the end of the work shift is also included. Since suiting up is required for every day of demolition work inside the contamination area, donning and doffing PPE is measured as a daily activity. Material costs for daily PPE for one D&D worker at the Hanford Site are shown in the table below:

Table C-1. Cost for PPE (per man/day)

Equipment	Cost Each Time Used ($)	No. Used Per Day	Cost Per Day ($)
Air-Purifying Respirator (PAPR)	71.06	1 ea	71.06
Face Shield	1.28	1 ea	1.28
Booties	0.62	2 pr	1.24
Coverall	5.00	2 ea	10.00
Double Coverall (5% of the time)			0.56
Hood	2.00	2 ea	4.00
Gloves (inner)	0.14	2 pr	.28
Gloves (outer)	1.30	2 pr	2.60
Gloves (liner)	0.29	2 pr	.58
Rubber Overshoe	1.38	2 pr	2.76
Total			**94.36**

Based on face shield price of $64/each and assumes 50 uses, and on a PAPR price of $903/each, assumes 50 uses, requires four cartridges per day at a cost of $14/each, and maintenance and inspection costs of $150 over the life of the PAPR. This assumes one worker remains outside the zone and does not suit up. The time spent changing PPE each day is based on observed times from previous jobs of large scale.

Remove Concrete Walls Surface to a Depth of 1/16-inch With the Grinder: Concrete removal was conducted with a crew consisting of 3 D & D workers. Two of these workers were fully suited in PPE (equipped with respirators) and worked inside the contamination area. The other worker acted as a 'runner' supporting the workers inside the contamination area by providing them with needed supplies and ensuring the air and vacuum lines remained operational. Removal work took place in Sample Room X at the C Reactor on 4.5 m^2 (54 ft^2) of walls surface. For the cost analysis, the area of removal is extrapolated to the area of walls surface removed with the scabbler or 12.2 m^2 (132 ft^2). Based on the type of contamination, it was only necessary to remove the concrete to 1.5 mm (1/16-in) deep. Costs for the removal work are calculated on a per-square-foot basis in order to establish a per-square-foot unit cost.

Monitor Workers & Waste Stream for Contamination: This activity involves one fully-suited RCT accompanying the D & D workers into the contamination area to monitor for changes in levels of contamination and worker exposure. It is a required activity under the standard operating procedures at Hanford. The RCT also monitored demolished material exiting the contamination area. All monitoring was done with conventional hand-held instrumentation (Eberline E-600 equipped with various probes). The RCT was retained for the full duration of the removal work in order to eliminate waiting for his services. The cost element is measured as one each and matches the total time for the demolition work.

Non-Productive Time: The non-productive time used in this cost analysis for both the innovative and the baseline is based on observed lost time for previous deployments (long term jobs of large size). An average loss per day of 3 hours is used to account for unexpected issues with the work, waiting on RCT support, etc.

DEMOBILIZATION (WBS 331.21)

Disassemble Equipment & Air Hoses & Decontaminate Equipment: This activity includes unwrapping disassembling, and decontaminating air and VAC-PAC™ HEPA filtration unit hoses as well as decontaminating the grinder. The activity involved 4 D & D workers and 2 RCTs.

WASTE DISPOSAL (WBS 331.18)

Disposal of Waste Material: This includes disposal of PPE, plastic wrapping and sleeving for air and VAC-PAC™ hoses, plastic sheeting around openings into the contamination area, and the waste concrete generated by the floor shaver. Disposal fees are those charged for final disposal at ERDF, or $60.00/ton. However, since a ton of waste material wasn't generated during the demonstration, a minimum waste disposal fee of $60.00 was used. Also, PPE and miscellaneous plastic sheeting and sleeving material were disposed of separately from the waste concrete, thus, two minimum disposal fees are used.

Table C-2. Improved technology cost summary - Flex LD 1509 FR Concrete Grinder

Work Breakdown Structure (WBS)	Unit Cost (UC)						Total Quantity (TQ)	Unit of Measure	Total Cost (TC)[1]	Crew	Comments
	Labor[2]		Equipment[3]		Other	Total UC					
	HRS	Rate	HRS	Rate							
Mobilization (WBS 331.01)								**Subtotal**	**$ 1,293**		
Collect Tools from Storage & Stage at the Work Site	8.17	$63.94	8.17	$22.88		$709.32	1	each	$709	2 D & D workers	
Move VAC-PAC™ & Air Compressor into the Work Area & Set Up	2	$159.85	2	$22.88		$365.46	1	each	$365	5 D & D workers	
Sleeve Vacuum & Air Hoses	2.2	$63.94	2.2	$22.88		$191.00	1	each	$191	2 D & D workers	
Wrap PAPRs	0.5	$31.97	0.5	$22.88		$27.43	1	day	$27	1 D & D worker	
DECONTAMINATION (WBS 331.17)								**Subtotal**	**$1,592**		
Pre-Work Briefing & Safety Meeting	0.25	$145.36	0.25	$22.88		$42.06	1	day	$42	3 D & D workers, 1 RCT	
Donning/Doffing Personal Protective Equipment (PPE)	1.77	$113.39	1.77	$22.88	$283	$524.20	1	day	$524	2 D & D workers, 1 RCT	Other rate incudes 3 sets of PPE @ $94.36 ea
Remove Concrete Walls Surface Down 1/16th-inch With the Unitec grinder	0.021	$95.91	0.021	$43.10		$2.92	132	square feet (ft^2)	$385	3 D & D workers	[4] 1/16th-inch removed in room X
Monitor Workers & Waste Stream for Radioactive	2.77	$49.45	2.77	$1.38		$140.90	1	each	$141	1 RCT	Fully-suited RCT monitoring the D & D workers in the rad-zone for the full amount of time they're in the rad-zone
Non Productive Time	2.97	$145.36	2.97	$22.88		$499.67	1	day	$500	3 D & D workers, 1 RCT	
DEMOBILIZATION (WBS 331.21)								**Subtotal**	**$749**		
Disassemble Equipment & Air Hoses & Decontaminate	3	$226.78	3	$22.88		$748.98	1	each	$749	4 D & D worker, 2 RCT	
WASTE DISPOSAL (WBS 331.18)								**Subtotal**	**$404**		
Disposal of PPE, Plastic Sheeting, & Sleeving	0.5	$113.39			$60	$116.70	1	each	$117	2 D & D workers, 1 RCT	Minimum waste disposal fee
Disposal of Concrete	2	$113.39			$60	$286.78	1	each	$287	2 D & D workers, 1 RCT	½ of a 55-gal drum
								TOTAL:	**$4,038**		

NOTES TO TABLE C-2:

1) TC=UC x TQ (where TC=total cost; UC=unit cost & TQ=total quantity)

2) Labor rates are $31.97/hr for a D & D worker and $49.45/hr for a RCT. Labor rates include base wages, fringes, and area overhead, but exclude BHI G&A and overhead.

3) Equipment rates are: $0.43/hr (amortized)for the grinder, $15.71/hr (amortized) for the VAC-PAC™ HEPA vacuum, air compressor $6.74/hr (standard site rates), and $1.38/hr (amortized) for the RCT detector instruments. It costs $20.22/hr for diamond grinding wheels when the device is in use, thus, the running cost for the grinder is $20.22 + $0.43 or $20.65/hr. Since both the floor shaver and the VAC-PAC™ are set up in the work area for the duration of the removal work, their combined hourly amortized cost is carried on all activities associated with completing the job.

4) Two D & D workers are required to operate the grinder within the contamination area. The third D & D worker supports the other two workers outside the contamination area. The third D & D worker is not required to be suited up in PPE.

Baseline Technology - Scaler & Scabbler

Special Note: *Two separate cost analysis tables are made for each of the baseline technologies. Many of the cost items defined below are common to the analysis for both technologies and identical in each cost table. Identical items are noted in parenthesis as applicable to both technologies. Those items unique to the demonstration of each technology are described separately.*

MOBILIZATION (WBS 331.01)

Move Scabbling Tools from Storage & Set Up in the Work Area: This includes time for loading equipment, airlines, and etc. from Connex™ boxes into a truck bed and moving the equipment to the work area. It also includes setting up the compressor and its air lines. The activity is measured as one each.

Set Up VAC-PAC™: This activity involves setting up the VAC-PAC™ and it's hoses and wrapping the hoses and equipment with plastic sheeting. It is measured as a one-each activity.

Sleeve Vacuum and Air Hoses: This activity involves using duct tape to attach plastic tubing to the vacuum and air hoses to prevent surface contamination of the hoses in the Rad Zone. It is measured as a one-each activity.

Wrap PAPRs: On a daily basis, 3 to 5 powered air purifying respirator (PAPR) units are required to be wrapped with a plastic cover along with the hose that delivers air to the mask. The measure is taken to prevent contaminating the units which, if it occurred, would mean discarding them. Costs for this item are measured on a daily basis.

DECONTAMINATION (WBS 331.17)

Pre-Work Briefing & Safety Meeting: This activity involves everyone who will work in or around the contamination area. It is a requirement to be performed every day of demolition work and, thus, is measured as a daily activity.

Don PPE: This cost item includes time for each of 2 D & D workers and 1 RCT to fully suit-up in personal protective clothing (PPE) for demolition work as well as material costs for the PPE. Since suiting up is required for every day of demolition work inside the contamination area, it too is measure as a daily activity. Material costs are the same as for the improved technology case.

Remove Concrete Walls Surface Down 1.5 mm (1/16th-inch) with the Scaler: Concrete removal was conducted with a crew consisting of 3 D & D workers. Two of the workers were fully suited in PPE (equipped with respirators) and worked inside the contamination area. The other worker acted as a 'runner' supporting the workers inside the contamination area by providing them with needed supplies and ensuring the air and vacuum lines remained operational. Removal work took place in at the C Reactor on 5 m^2 (59 ft^2) of walls surface. For the cost analysis, the area of removal is extrapolated to the area of walls surface removed with the scabbler or 12.2 m^2 (132 ft^2). Based on the type of contamination, it was only necessary to remove the concrete to 1.5 mm (1/16 in.) depth. Removal time includes the time it took to move the scaler from spot to spot within Sample Rooms A and B. Costs for the removal work are calculated on a per-square-foot basis in order to establish a per-square-foot unit cost.

Remove Concrete Walls Surface Down 1.5 mm (1/16th-inch) with the Scabbler: As with the scaler, concrete removal was conducted with a crew of 3 D & D workers. Removal also took place in Sample Rooms A and B at the C Reactor, but on 12.2 m^2 (132 ft^2) of walls surface. (As noted for the innovative technology and baseline technology , this area of removal forms the basis of comparison for all three technologies). It was also necessary to remove the concrete walls surface to only 1.5 mm (1/16 in.) depth with this technology, but because of limitations of the technology, the device removed material ranging from 1.5 to 3 mm (1/16 to 1/8 in.) in depth. Removal time includes the time it took to move the scabbler from spot to spot within Sample Rooms A and B.

Costs for the removal work are calculated on a per-square-foot basis in order to establish a per-square-foot unit cost.

Monitor Workers & Waste Stream for Contamination: This activity involves one fully-suited RCT accompanying the D & D workers into the contamination area to monitor for changes in levels of contamination and worker exposure. It is a required activity under the standard operating procedures at Hanford. The RCT also monitored demolished material exiting the contamination area. All monitoring was done with conventional hand held instrumentation (Eberline E-600 equipped with various probes). The RCT was retained for the full duration of the removal work in order to eliminate waiting for his services. The cost element is measured as one each and matches the total time for the demolition work.

Non-Productive Time: Same assumption as for innovative technology.

DEMOBILIZATION (WBS 331.21)

Disassemble Equipment & Air Hoses & Decontaminate Equipment: This activity includes unwrapping, disassembling, and decontaminating air and VAC-PAC™ hoses as well as decontaminating the scabbling device.

WASTE DISPOSAL (WBS 331.18)

Disposal of Waste Material: This includes disposal of PPE, plastic wrapping and sleeving for air and VAC-PAC™ hoses, plastic sheeting around openings into the contamination area, and the waste concrete generated by the scabbler. Disposal fees are those charged for final disposal at ERDF, or $60.00/ton. However, since a ton of waste material wasn't generated during the demonstration, a minimum waste disposal fee of $60.00 was used. Also, PPE and miscellaneous plastic sheeting and sleeving material were disposed of separately from the waste concrete, thus, two minimum disposal fees are used.

Table C-3.1 Baseline technology cost Summary - scaler

Work Breakdown Structure (WBS)	Unit Cost (UC)						Total Quantity (TQ)	Unit of Measure	Total Cost (TC)[1]	Crew[5]	Comments
	Labor[2]		Equipment[3]		Other	Total UC					
	HRS	Rate	HRS	Rate							
MOBILIZATION (WBS 331.01)								**Subtotal**	**$ 1,339**		
Collect Tools from Storage & Stage at the Work Site	8.33	$63.94	8.33	$23.18		$725.71	1	each	$726	2 D & D workers	
Move VAC-PAC™ & Air Compressor into the Work Area & Set Up	2	$159.85	2	$23.18		$366.06	1	each	$366	5 D & D workers	
Sleeve Vacuum & Air Hoses	2.2	$63.94	2.2	$23.18		$191.66	1	each	$192	2 D & D workers	
Wrap PAPRs	0.5	$31.97	0.5	$23.18		$27.58	2	day	$55	1 D & D worker	
DECONTAMINATION (WBS 331.17)								Subtotal	$4,198		
Pre-Work Briefing & Safety Meeting	0.25	$145.36	0.25	$23.18		$42.14	2	day	$84	3 D & D workers, 1 RCT	
Donning/Doffing Personal Protective Equipment (PPE)	1.77	$113.39	1.77	$23.18	$283	$581.32	2	day	$1,163	2 D & D workers, 1 RCT	Other rate incudes 3 sets of PPE $94.36 ea
Remove Concrete Walls Surface Down 1/16th-inch With the Scaler	0.0847	$95.91	0.0847	$27.71		$10.47	132	square feet (ft^2)	$1,382	3 D & D workers (5)	Removed in Sample Rooms A & B
Monitor Workers & Waste Stream for Radioactive	11.18	$49.45	11.18	$1.38		$568.30	1	each	$568	1 RCT	Fully-suited RCT monitoring the D & D workers in the rad-zone for the full amount of time they're in the rad-zone
Non-Productive Time	2.97	$145.36	2.97	$23.18		$500.56	2	day	$1,001	3 D & D workers, 1 RCT	
DEMOBILIZATION (WBS 331.21)								**Subtotal**	**$750**		
Disassemble Equipment & Air Hoses & Decontaminate	3	$226.78	3	$23.18		$749.88	1	each	$750	4 D & D worker, 2 RCT	
WASTE DISPOSAL (WBS 331.18)								**Subtotal**	**$404**		
Disposal of PPE, Plastic Sheeting, & Sleeving	0.5	$113.39			$60	$116.70	1	each	$117	2 D & D workers, 1 RCT	Minimum waste disposal fee
Disposal of Concrete	2	$113.39			$60	$286.78	1	each	$287	2 D & D workers, 1 RCT	½-of a 55-gal drum
								TOTAL:	**$6,690**		

Table C-3.2 Baseline technology cost summary - scabbler

Work Breakdown Structure (WBS)	Unit Cost (UC)						Total Quantity (TQ)	Unit of Measure	Total Cost (TC)[1]	Crew[5]	Comments
	Labor[2]		Equipment[4]		Other	Total UC					
	HRS	Rate	HRS	Rate							
MOBILIZATION (WBS 331.01)								**Subtotal**	**$ 1,391**		
Collect Tools from Storage & Stage at the Work Site	8.33	$63.94	8.33	$27.02		$757.70	1	each	$758	2 D & D workers	
Move VAC-PAC™ & Air Compressor into the Work Area & Set Up	2	$159.85	2	$27.02		$373.74	1	each	$374	5 D & D workers	
Sleeve Vacuum & Air Hoses	2.2	$63.94	2.2	$27.02		$200.11	1	each	$200	2 D & D workers	
Wrap PAPRs	0.5	$31.97	0.5	$27.02		$29.50	2	day	$59	1 D & D worker	
DECONTAMINATION (WBS 331.17)								**Subtotal**	**$4,101**		
Pre-Work Briefing & Safety Meeting	0.25	$145.36	0.25	$27.02		$43.10		day	$86	3 D & D workers, 1 RCT	
Donning/Doffing Personal Protective Equipment (PPE)	1.77	$113.39	1.77	$27.02	$283	$531.53	2	day	$1,063	2 D & D workers, 1 RCT	Other rate incudes 3 sets of PPE $94.36 ea
Remove Concrete Walls Surface	0.0833	$95.91	0.0833	$28.55		$10.37	132	square feet (ft^2)	$1,369	3 D & D workers	1/16th to 1/8 inch removed in Sample Rooms A & B
Monitor Workers & Waste Stream for Radioactive	11.18	$49.45	11.18	$1.38		$558.91	1	each	$559	1 RCT	Fully-suited RCT monitoring the D & D workers in the rad-zone for the full amount of time they're in the rad-zone
Non-Productive Time	2.97	$145.36	2.97	$27.02		$511.97	2	day	$1,024	3 D & D workers, 1 RCT	
DEMOBILIZATION (WBS 331.21)								**Subtotal**	**$761**		
Disassemble Equipment & Air Hoses & Decontaminate	3	$226.78	3	$27.02		$761.40	1	each	$761	4 D & D worker, 2 RCT	
WASTE DISPOSAL (WBS 331.18)								Subtotal	**$404**		
Disposal of PPE, Plastic Sheeting, & Sleeving	0.5	$113.39			$60	$116.70	1	each	$117	2 D & D workers, 1 RCT	Minimum waste disposal fee
Disposal of Concrete	2	$113.39			$60	$286.78	1	each	$287	2 D & D workers, 1 RCT	½ of a 55-gal drum
								TOTAL:	**$6,656**		

NOTES TO TABLES C-3.1 & C-3.2:

(1) TC=UC x TQ (where TC=total cost; UC=unit cost & TQ=total quantity)

(2) Labor rates are $31.97/hr for a D & D worker and $49.45/hr for a RCT. Labor rates include base wages, fringes, and area overhead, but exclude Environmental Restoration Contractor G&A and overhead.

(3) Equipment rates for Baseline Technology are: $0.73/hr (amortized) for the scaler, $15.71/hr (amortized) for the VAC-PAC™ HEPA vacuum, air compressor, $6.74/hr (based on standard rates for Hanford), and $1.38/hr (amortized) for the RCT detector instruments. It costs $4.53/hr for carbide flaps when the device is in use, thus, the running cost for the scaler is $0.73 + $4.53 or $5.26/hr. Since both the scaler and the VAC-PAC™ are set up in the work area for the duration of the removal work, their combined hourly amortized cost is carried on all activities associated with completing the job.

(4) Equipment rates for Baseline Technology are: $4.57/hr (amortized) for the scabbler, $15.71/hr (amortized) for the VAC-PAC™ HEPA vacuum, air compressor, $6.74 (based on standard rates for Hanford), and $1.38/hr (amortized) for the RCT detector instruments. It costs $1.53/hr for scabbler bits when the device is in use, thus, the running cost for the scabbler is $4.57 + $1.53 or $6.10/hr. Since both the scabbler and the VAC-PAC are set up in the work area for the duration of the removal work, their combined hourly amortized cost is carried on all activities associated with completing the job.

(5) Two D & D workers are required to operate the scaler or scabbler within the contamination area. The third D & D worker acts as a 'runner' supporting the other two workers from outside the contamination area. The third D & D worker is not required to be suited up in PPE.